1. Fórmulas

Box 1 - Fórmulas matemáticas

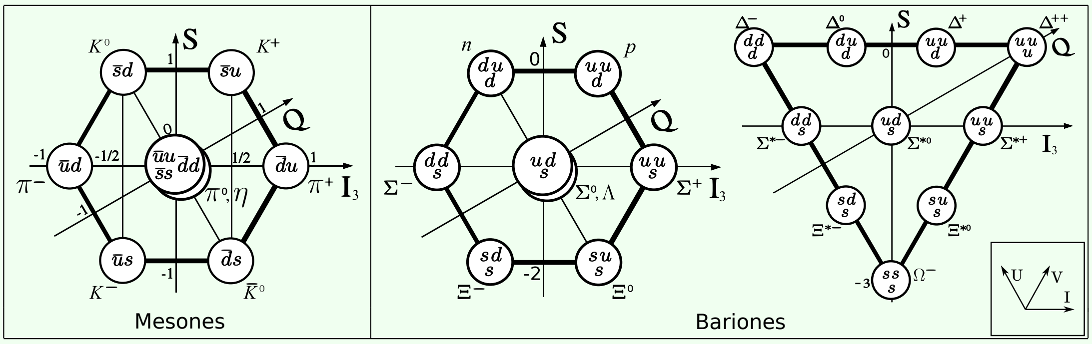
$$\left(e^{A}\right)^{\dagger}=e^{A^{\dagger}} \qquad \det e^{A}=e^{\operatorname{Tr} A} \qquad \frac{d}{dx}e^{xA}=Ae^{xA} \qquad e^{A}e^{B}=e^{A+B+\frac{1}{2}[A,B]+\dots} \qquad \left(e^{A}\right)^{-1}=e^{-A}$$

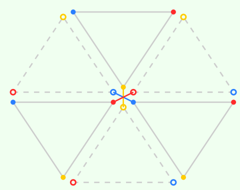
Box 2 - Fórmulas relatividad

$$p^{\mu}\sim\begin{bmatrix}E/c\\ \boldsymbol{p}\end{bmatrix}=m\gamma\begin{bmatrix}c\\ \boldsymbol{v}\end{bmatrix}\underbrace{\sim\begin{bmatrix}i\partial^{0}\\ -i\boldsymbol{\nabla}\end{bmatrix}}_{\text{En cuántica}} \qquad \frac{E^{2}}{c^{2}}=\boldsymbol{p}^{2}+m^{2}c^{2} \qquad \begin{cases}\boldsymbol{\beta}=\dfrac{\boldsymbol{v}}{c}\\ \gamma=\left(1-\beta^{2}\right)^{-1/2}\end{cases}$$

$$\begin{cases}\partial_{\mu}\overset{\text{def}}{=}\dfrac{\partial}{\partial x^{\mu}}\\ \partial^{\mu}\overset{\text{def}}{=}\eta^{\mu\nu}\dfrac{\partial}{\partial x^{\nu}}\sim\begin{bmatrix}\partial_{t}\\ -\boldsymbol{\nabla}\end{bmatrix}\end{cases} \qquad \Box^{2}=\partial^{\mu}\partial_{\mu} \qquad x_{\mu}=\eta_{\mu\nu}x^{\nu} \qquad \begin{cases}x^{\mu}\sim\begin{bmatrix}t\\ \boldsymbol{x}\end{bmatrix} & \text{Contravariante}\\ x_{\mu}\sim\begin{bmatrix}t\\ -\boldsymbol{x}\end{bmatrix} & \text{Covariante}\end{cases}$$

Box 3 - Fórmulas isospín y SU(3)





$$3\otimes3\otimes3=10_{\mathrm{S}}\oplus8_{\mathrm{MA}}\oplus8_{\mathrm{MS}}\oplus1_{\mathrm{A}} \qquad 2\otimes2\otimes2=4_{\mathrm{S}}\oplus2_{\mathrm{MA}}\oplus2_{\mathrm{MS}} \qquad 3\otimes\bar{3}=8\oplus1$$

$$\left[\underline{\overline{\Lambda_i}},\underline{\overline{\Lambda_j}}\right]=if_{ijk}\,\underline{\overline{\Lambda_k}} \qquad \underline{\overline{\Lambda_i}}\sim\begin{cases}\lambda_i & \text{En quarks}\\ \bar{\lambda}_i=-\lambda_i^{*} & \text{En antiquarks}\end{cases}$$

$$\begin{cases}f_{123}=1\\ f_{147}=-f_{156}=f_{246}=f_{257}=f_{345}=-f_{367}=\dfrac{1}{2}\\ f_{458}=f_{678}=\dfrac{\sqrt{3}}{2}\\ f_{ijk}=-f_{jik}=-f_{ikj}\ \text{etc.}\end{cases} \qquad \begin{cases}\underline{I_{\pm}}=\dfrac{\underline{\overline{\Lambda_1}}\pm i\,\underline{\overline{\Lambda_2}}}{2}\\ \underline{U_{\pm}}=\dfrac{\underline{\overline{\Lambda_6}}\pm i\,\underline{\overline{\Lambda_7}}}{2}\\ \underline{V_{\pm}}=\dfrac{\underline{\overline{\Lambda_4}}\pm i\,\underline{\overline{\Lambda_5}}}{2}\end{cases}$$

$$\text{Quarks}\rightarrow\begin{cases}\underline{I_+}\begin{Bmatrix}|u\rangle\\|d\rangle\\|s\rangle\end{Bmatrix}=\begin{Bmatrix}0\\|u\rangle\\0\end{Bmatrix}\\ \underline{I_-}\begin{Bmatrix}|u\rangle\\|d\rangle\\|s\rangle\end{Bmatrix}=\begin{Bmatrix}|d\rangle\\0\\0\end{Bmatrix}\end{cases} \begin{cases}\underline{U_+}\begin{Bmatrix}|u\rangle\\|d\rangle\\|s\rangle\end{Bmatrix}=\begin{Bmatrix}0\\0\\|d\rangle\end{Bmatrix}\\ \underline{U_-}\begin{Bmatrix}|u\rangle\\|d\rangle\\|s\rangle\end{Bmatrix}=\begin{Bmatrix}0\\|s\rangle\\0\end{Bmatrix}\end{cases} \begin{cases}\underline{V_+}\begin{Bmatrix}|u\rangle\\|d\rangle\\|s\rangle\end{Bmatrix}=\begin{Bmatrix}0\\0\\|u\rangle\end{Bmatrix}\\ \underline{V_-}\begin{Bmatrix}|u\rangle\\|d\rangle\\|s\rangle\end{Bmatrix}=\begin{Bmatrix}|s\rangle\\0\\0\end{Bmatrix}\end{cases}$$

$$\text{Antiquarks}\rightarrow\begin{cases}\underline{I_+}\begin{Bmatrix}|\bar{u}\rangle\\|\bar{d}\rangle\\|\bar{s}\rangle\end{Bmatrix}=\begin{Bmatrix}-|\bar{d}\rangle\\0\\0\end{Bmatrix}\\ \underline{I_-}\begin{Bmatrix}|\bar{u}\rangle\\|\bar{d}\rangle\\|\bar{s}\rangle\end{Bmatrix}=\begin{Bmatrix}0\\-|\bar{u}\rangle\\0\end{Bmatrix}\end{cases} \begin{cases}\underline{U_+}\begin{Bmatrix}|\bar{u}\rangle\\|\bar{d}\rangle\\|\bar{s}\rangle\end{Bmatrix}=\begin{Bmatrix}0\\-|\bar{s}\rangle\\0\end{Bmatrix}\\ \underline{U_-}\begin{Bmatrix}|\bar{u}\rangle\\|\bar{d}\rangle\\|\bar{s}\rangle\end{Bmatrix}=\begin{Bmatrix}0\\0\\-|\bar{d}\rangle\end{Bmatrix}\end{cases} \begin{cases}\underline{V_+}\begin{Bmatrix}|\bar{u}\rangle\\|\bar{d}\rangle\\|\bar{s}\rangle\end{Bmatrix}=\begin{Bmatrix}-|\bar{s}\rangle\\0\\0\end{Bmatrix}\\ \underline{V_-}\begin{Bmatrix}|\bar{u}\rangle\\|\bar{d}\rangle\\|\bar{s}\rangle\end{Bmatrix}=\begin{Bmatrix}0\\0\\-|\bar{u}\rangle\end{Bmatrix}\end{cases}$$

Box 4 - Fórmulas de ecuaciones de onda relativistas

Klein-Gordon

$$\left(\partial^\mu\partial_\mu + m^2\right)\phi = 0$$

Dirac

$$\begin{cases}\left(i\gamma^\mu\partial_\mu - m\right)\psi = 0\\ \overline{\psi}\left(\overleftarrow{\partial}_\mu\gamma^\mu i + m\right) = 0\end{cases}\qquad \overline{\psi}\overset{\text{def}}{=}\psi^\dagger\gamma^0 \qquad \overline{\underline{\mathscr{H}_{\text{Dirac libre}}}} = \gamma^0 m + \gamma^0\boldsymbol{\gamma}\cdot\overline{\underline{\boldsymbol{p}}} \qquad J^\mu = \overline{\psi}\gamma^\mu\psi \qquad \partial_\mu J^\mu = 0$$

Soluciones base Dirac → $\begin{cases}u_i = e^{-ikx}\begin{bmatrix}\xi_i\\ \frac{\boldsymbol{k}\cdot\boldsymbol{\sigma}}{k^0+m}\xi_i\end{bmatrix} & E>0\\ v_i = e^{ikx}\begin{bmatrix}\frac{\boldsymbol{k}\cdot\boldsymbol{\sigma}}{k^0+m}\xi_i\\ \xi_i\end{bmatrix} & E<0\end{cases}$ $\quad\begin{cases}\xi_1 = \begin{bmatrix}1\\0\end{bmatrix}\\ \xi_2 = \begin{bmatrix}0\\1\end{bmatrix}\end{cases}$ Espín → $\begin{cases}\boldsymbol{S} = \frac{1}{2}\boldsymbol{\Sigma}\\ \boldsymbol{\Sigma}\sim\begin{bmatrix}\boldsymbol{\sigma} & 0\\ 0 & \boldsymbol{\sigma}\end{bmatrix}\end{cases}$

$$\begin{cases}\{\gamma^\mu,\gamma^\nu\} = 2\eta^{\mu\nu}\mathbb{1} \leftarrow \text{Clifford}\\ (\gamma^\mu)^2 = \mathbb{1}\eta^{\mu\mu}\\ (\gamma^\mu)^\dagger = \begin{cases}-\gamma^\mu & \text{para } \mu\neq 0\\ \gamma^\mu & \text{para } \mu = 0\end{cases}\\ (\gamma^\mu)^\dagger = \gamma^0\gamma^\mu\gamma^0\\ \gamma^5 \overset{\text{def}}{=} i\gamma^0\gamma^1\gamma^2\gamma^3 \qquad \left(\gamma^5\right)^2 = \mathbb{1}\\ \{\gamma^5,\gamma^\mu\} = 0\end{cases}$$

Base de Dirac: $\gamma^0 = \begin{bmatrix}\mathbb{1} & \\ & -\mathbb{1}\end{bmatrix}\quad \gamma^i = \begin{bmatrix} & \sigma_i\\ -\sigma_i & \end{bmatrix}$

Base de Weyl: $\gamma^0 = \begin{bmatrix} & \mathbb{1}\\ \mathbb{1} & \end{bmatrix}\quad \gamma^i = \begin{bmatrix} & \sigma_i\\ -\sigma_i & \end{bmatrix}$

$$\sigma_x = \begin{bmatrix}0 & 1\\ 1 & 0\end{bmatrix}\quad \sigma_y = \begin{bmatrix}0 & -i\\ i & 0\end{bmatrix}\quad \sigma_z = \begin{bmatrix}1 & 0\\ 0 & -1\end{bmatrix}\quad \begin{cases}[\sigma_i,\sigma_j] = 2i\varepsilon_{ijk}\sigma_k\\ \{\sigma_i,\sigma_j\} = 2\delta_{ij}\mathbb{1}\end{cases}$$

$$S_\Lambda^{-1}\gamma^\mu S_\Lambda = \Lambda^\mu{}_\nu\gamma^\nu$$

$$\begin{cases}\left\lceil\Psi'\right\rfloor_{x'} = S_\Lambda\left\lceil\Psi\right\rfloor_{x(x')}\\ \left\lceil\overline{\Psi'}\right\rfloor_{x'} = \left\lceil\overline{\Psi}\right\rfloor_{x(x')}S_\Lambda^{-1}\end{cases}\qquad S_\Lambda = \exp\left(-\frac{i}{2}\omega_{\alpha\beta}\Sigma^{\alpha\beta}\right)\qquad \Sigma^{\alpha\beta} = \frac{i}{4}\left[\gamma^\alpha,\gamma^\beta\right]\qquad \omega_{\alpha\beta}\sim\begin{bmatrix}0 & \xi_1 & \xi_2 & \xi_3\\ -\xi_1 & 0 & \theta_3 & \theta_2\\ -\xi_2 & -\theta_3 & 0 & \theta_1\\ -\xi_3 & -\theta_2 & -\theta_1 & 0\end{bmatrix}$$

Parity operator → $\begin{cases}\mathcal{P}\psi \overset{\text{def}}{=} \gamma^0\psi(t,-\boldsymbol{x})\\ \mathcal{P}\overline{\psi} = \overline{\psi}(t,-\boldsymbol{x})\gamma^0\end{cases}$ $\quad\boxed{\gamma^5 = i\gamma^0\gamma^1\gamma^2\gamma^3 \to \text{Quiralidad}\qquad P_\pm = \frac{\mathbb{1}\pm\gamma^5}{2}}\quad h = \boldsymbol{\Sigma}\cdot\hat{\boldsymbol{p}} \to$ Helicidad

Box 5 - Fórmulas de formulación lagrangiana

Noether → $\begin{cases}\varepsilon J^\mu = \sum_i \frac{\partial\mathscr{L}}{\partial(\partial_\mu\phi_i)}\delta\phi_i(\varepsilon) + F(\varepsilon)^\mu\\ \delta\mathscr{L} = \partial_\mu F^\mu \quad \varepsilon\to 0 \text{ es el parámetro}\end{cases}$ $\quad\partial_\mu\frac{\partial\mathscr{L}}{\partial(\partial_\mu\phi)} = \frac{\partial\mathscr{L}}{\partial\phi}\quad$ $\begin{matrix}\mathscr{L}_{\text{Dirac}} = \overline{\Psi}\left(i\gamma^\mu\partial_\mu - m\right)\Psi\\ \mathscr{L}_{\text{KG}} = \partial_\mu\phi^*\partial^\mu\phi - m^2\phi^*\phi\end{matrix}$

Box 6 - Fórmulas gauge no abeliano

$$D_\mu \overset{\text{def}}{=} \partial_\mu + igA_\mu \qquad \Omega \overset{\text{def}}{=} \exp\left(-ig\alpha^a(x)T_a\right)\qquad D'_\mu = \Omega D_\mu\Omega^{-1}\qquad A_\mu \equiv A^a{}_\mu T_a \qquad A'^a{}_\mu = A^a{}_\mu - \frac{1}{g}\partial_\mu\alpha^a$$

$$T_a^\dagger = T_a \qquad [T_a,T_b] = if_{abc}T^c \qquad f_{abc}\text{ totalmente antisimétrico para }\mathfrak{su}(N)$$

$$A'_\mu = \Omega A_\mu\Omega^{-1} - \frac{1}{ig}\left(\partial_\mu\Omega\right)\Omega^{-1} \Rightarrow \left(A^a{}_\mu\right)' = A^a{}_\mu + \partial_\mu\alpha^a + g\alpha^b A^c{}_\mu f^a{}_{bc}$$

$$G_{\mu\nu} \overset{\text{def}}{=} \frac{1}{ig}\left[D_\mu, D_\nu\right] \equiv F_{\mu\nu} + ig\left[A_\mu, A_\nu\right] = G^a{}_{\mu\nu}T_a = \boldsymbol{G}_{\mu\nu}\cdot\boldsymbol{T}$$

$$G^a{}_{\mu\nu} = \partial_\mu G^a{}_\nu - \partial_\nu G^a{}_\mu - g f^a{}_{bc} G^b{}_\mu G^c{}_\nu \qquad (G^a{}_\mu)' = G^a{}_\mu - \frac{1}{g}\partial_\mu \alpha^a - f_a{}^{bc}\alpha_b G_{c\mu} \qquad (G_{\mu\nu})' = \Omega G_{\mu\nu}\Omega^{-1}$$

$$\mathscr{L}_{\text{YM}} = (D^\mu\Phi)^\dagger (D_\mu\Phi) - m^2\Phi^\dagger\Phi - \frac{1}{2}\text{Tr}\,(G_{\mu\nu}G^{\mu\nu})$$

Box 7 - Fórmulas modelo estándar

$$\begin{cases} \mathscr{L}_{\text{QCD}} = \sum\limits_{q\in\text{quarks}} (\bar{q} i\gamma^\mu D_{S\mu} q) - \frac{1}{4} G^a{}_{\mu\nu} G_a{}^{\mu\nu} \\ \mathscr{L}_{\text{EW}} = \sum\limits_{\Psi\in\text{dobeltes E.W.}} \left(\overline{\Psi_L} i\gamma^\mu D_L^{(\Psi)}{}_\mu \Psi_L + \overline{\Psi_R} i\gamma^\mu D_R^{(\Psi)}\Psi_R\right) - \frac{1}{4}B_{\mu\nu}B^{\mu\nu} - \frac{1}{4}W^a{}_{\mu\nu}W_a{}^{\mu\nu} \\ \mathscr{L}_{\text{Higgs}} = (D_{h\mu}\Phi)^\dagger (D_h{}^\mu \Phi) - \lambda\left(\Phi^\dagger\Phi - \frac{v^2}{2}\right)^2 + \underbrace{G_e\left(\overline{\Psi_L}\Phi\psi_R + \overline{\psi_R}\Phi^\dagger\Psi_L\right)}_{\text{Leptones}} + \underbrace{G_u\left(\overline{q_L}\frac{h+v}{\sqrt{2}}q_R + \overline{q_R}\frac{h+v}{\sqrt{2}}q_L\right)}_{\text{Quarks}} \end{cases}$$

$$\begin{cases} \text{quarks} = \{u,d,c,s,t,b\} \qquad u \equiv \begin{bmatrix} u_{\text{red}} \\ u_{\text{green}} \\ u_{\text{blue}} \end{bmatrix}, d = \dots \\ \text{dobletes E.W.} = \left\{\begin{bmatrix}\nu_e\\ e\end{bmatrix}, \begin{bmatrix}\nu_\mu\\ \mu\end{bmatrix}, \begin{bmatrix}\nu_\tau\\ \tau\end{bmatrix}, \begin{bmatrix}u\\ d'\end{bmatrix}, \begin{bmatrix}c\\ s'\end{bmatrix}, \begin{bmatrix}t\\ b'\end{bmatrix}\right\} \\ \Phi = \begin{bmatrix}\phi^+\\ \phi^0\end{bmatrix} \in \mathbb{C}^2, \Phi \to \begin{bmatrix}0\\ \frac{h+v}{\sqrt{2}}\end{bmatrix} \end{cases} \qquad \begin{bmatrix}d'\\ s'\\ b'\end{bmatrix} = \begin{bmatrix} C & a & b \\ i & b & b \\ ☹ & o & ☺ \end{bmatrix} \begin{bmatrix}d\\ s\\ b\end{bmatrix}$$

$$\text{Gauge fields} \to \begin{cases} B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu & \to B \text{ field } \exists! \\ W^a{}_{\mu\nu} \sim \boldsymbol{W}_{\mu\nu} = \partial_\mu \boldsymbol{W}_\nu - \partial_\nu \boldsymbol{W}_\mu - \frac{g_w}{2}\boldsymbol{W}_\mu \times \boldsymbol{W}_\nu & \to \text{Weakons } a \in \{1,2,3\} \\ G^a{}_{\mu\nu} = \partial_\mu G^a{}_\nu - \partial_\nu G^a{}_\mu - \frac{g_s}{2} f^a{}_{bc} G^b{}_\mu G^c{}_\nu & \to \text{Gluons } a \in \{1,\dots,8\} \end{cases}$$

$$\text{Notaciones habituales} \to \begin{cases} W_{\mu\nu} \equiv W^a{}_{\mu\nu}\sigma_a \equiv \boldsymbol{W}_{\mu\nu}\cdot\boldsymbol{\sigma} \\ G^a{}_{\mu\nu} \equiv G^a{}_{\mu\nu}\lambda_a \end{cases} \qquad \begin{cases} W^a{}_{\mu\nu}W_a{}^{\mu\nu} \equiv \frac{1}{2}\text{Tr}\,(W_{\mu\nu}W^{\mu\nu}) \\ G^a{}_{\mu\nu}G_a{}^{\mu\nu} \equiv \frac{1}{2}\text{Tr}\,(G_{\mu\nu}G^{\mu\nu}) \end{cases}$$

$$\begin{cases} \text{Strong gauge:} \quad D_{S\mu} = \partial_\mu + i\frac{g_s}{2}G^a{}_\mu\lambda_a \qquad [T_a, T_b] = i f_{abc}T^c \quad \Rightarrow \quad T_{\text{strong}} = \lambda, T_{\text{weak}} = \sigma \\ \text{Electroweak gauge:} \quad \begin{cases} D_L^{(\Psi)}{}_\mu = \partial_\mu + i\frac{g'}{2}Y_L^{(\Psi)}B_\mu + i\frac{g_w}{2}\sigma_a W^a{}_\mu & \to \text{Left components} \\ D_R^{(\Psi)}{}_\mu = \partial_\mu + i\frac{g'}{2}Y_R^{(\Psi)}B_\mu & \to \text{Right components} \end{cases} \\ \text{Higgs gauge:} \quad D_{h\mu} = \partial_\mu + i\frac{g'}{2}Y_h B_\mu + i\frac{g_w}{2}\sigma_a W^a{}_\mu \end{cases}$$

$$\text{Hypercharge} \to \begin{cases} Y_L^{(\Psi)} = \begin{bmatrix} y_{L1}^{(\Psi)} & \\ & y_{L2}^{(\Psi)} \end{bmatrix} \in \mathbb{R}^2 \\ Y_R^{(\Psi)} = \begin{bmatrix} y_{R1}^{(\Psi)} & \\ & y_{R2}^{(\Psi)} \end{bmatrix} \in \mathbb{R}^2 \end{cases} \qquad \begin{matrix} Y_L^{(\text{leptones})} = \begin{bmatrix} -1 & \\ & -1 \end{bmatrix} & Y_R^{(\text{leptones})} = \begin{bmatrix} 0 & \\ & -2 \end{bmatrix} \\ Y_L^{(\text{quarks})} = \begin{bmatrix} \frac{1}{3} & \\ & \frac{1}{3} \end{bmatrix} & Y_R^{(\text{quarks})} = \begin{bmatrix} \frac{4}{3} & \\ & -\frac{2}{3} \end{bmatrix} \\ Y_h = \mathbb{1} & \end{matrix}$$

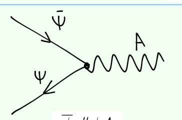
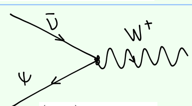
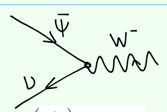
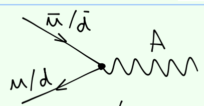
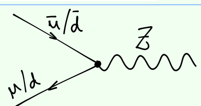
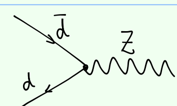
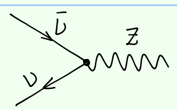
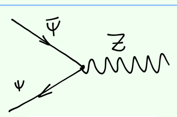
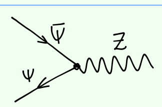
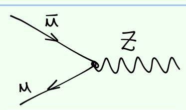
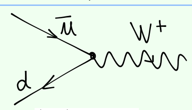
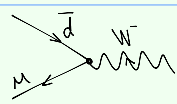
$$\begin{bmatrix} B_\mu \\ W^3{}_\mu \end{bmatrix} = \underbrace{\begin{bmatrix} \cos\theta_W & -\sin\theta_W \\ \sin\theta_W & \cos\theta_W \end{bmatrix}}_{M^{-1}=M^T} \begin{bmatrix} A_\mu \\ Z_\mu \end{bmatrix} \qquad \begin{bmatrix} W^1{}_\mu \\ W^2{}_\mu \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ i & -i \end{bmatrix}\begin{bmatrix} W^+{}_\mu \\ W^-{}_\mu \end{bmatrix} \qquad \begin{cases} \Psi_L = P_L\Psi \\ \Psi_R = P_R\Psi \end{cases} \qquad \begin{cases} P_L = \frac{\mathbb{1}-\gamma^5}{2} \\ P_R = \frac{\mathbb{1}+\gamma^5}{2} \end{cases}$$

$$|\,e\,| = g' \cos\theta_W = g_w \sin\theta_W = Q_\psi - Q_\nu \qquad \mathscr{L} = \dots + Q_\psi \overline{\psi}\gamma^\mu \psi A_\mu + \dots$$

$Q^{\text{lepton}}_{\text{up-type}} = 0$	$Q^{\text{quark}}_{\text{up-type}} = -\frac{2}{3}\,|\,e\,|$
$Q^{\text{lepton}}_{\text{down-type}} = |\,e\,|$	$Q^{\text{quark}}_{\text{down-type}} = \frac{1}{3}\,|\,e\,|$

$$m_W = \frac{v g_w}{2} \qquad m_z = \frac{v}{2}\sqrt{g_w^2 + g'^2} \qquad m_A = 0 \qquad m_e = \frac{G_e v}{\sqrt{2}}$$

Box 8 - Vértices modelo estándar

$\overline{\Psi_L} i\gamma^\mu D_L^{(\Psi)}{}_\mu \Psi_L + \overline{\Psi_R} i\gamma^\mu D_R^{(\Psi)} \Psi_R$ para leptones			$\overline{\Psi_L} i\gamma^\mu D_L^{(\Psi)}{}_\mu \Psi_L + \overline{\Psi_R} i\gamma^\mu D_R^{(\Psi)} \Psi_R$ para quarks		
 $e\overline{\psi}\gamma^\mu\psi A_\mu$	 $\left(-\frac{g_w}{\sqrt{2}}\right)\overline{\nu_L}\gamma^\mu\psi_L W^+{}_\mu$	 $\left(-\frac{g_w}{\sqrt{2}}\right)\overline{\psi_L}\gamma^\mu\nu_L W^-{}_\mu$	 $\left(-\frac{2}{3}e\right)\overline{u}\gamma^\mu u A_\mu$ / $\frac{e}{3}\overline{d}\gamma^\mu d A_\mu$	 $\left(\frac{2g'\sin\theta_W}{3}\right)\overline{u_R}\gamma^\mu u_R Z_\mu$ / $\left(-\frac{g'\sin\theta_W}{3}\right)\overline{d_R}\gamma^\mu d_R Z_\mu$	 $\left(\frac{g'\sin\theta_W}{6}+\frac{g_w\cos\theta_W}{2}\right)\overline{d_L}\gamma^\mu d_L Z_\mu$
 $\left(-\frac{g'\sin\theta_W}{2}-\frac{g_w\cos\theta_W}{2}\right)\overline{\nu_L}\gamma^\mu\nu_L Z_\mu$	 $(-g'\sin\theta_W)\,\overline{\psi_R}\gamma^\mu\psi_R Z_\mu$	 $\left(-\frac{g'\sin\theta_W}{2}+\frac{g_w\cos\theta_W}{2}\right)\overline{\psi_L}\gamma^\mu\psi_L Z_\mu$	 $\left(\frac{g'\sin\theta_W}{6}-\frac{g_w\cos\theta_W}{2}\right)\overline{u_L}\gamma^\mu u_L Z_\mu$	 $\left(-\frac{g_w}{\sqrt{2}}\right)\overline{u_L}\gamma^\mu d_L W^+{}_\mu$	 $\left(-\frac{g_w}{\sqrt{2}}\right)\overline{d_L}\gamma^\mu u_L W^-{}_\mu$